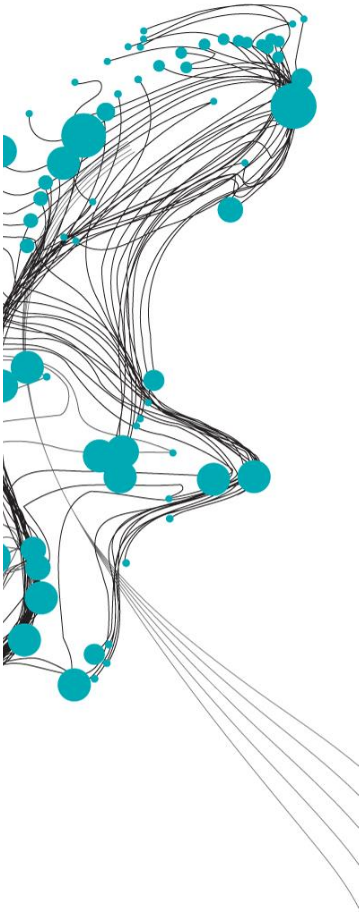
MODELLING SPATIOTEMPORAL VARIABILITY OF BED ROUGHNESS AND ITS ROLE IN THE MORPHOLOGICAL DEVELOPMENT OF TIDAL SAND WAVES



The sandy seabed of many coastal seas consists of a variety of rhythmic bed patterns and among the largest are sand waves. To study their morphological behaviour, process-based models are setup. However, some physical processes, such as the bed roughness, remain simplified. It is often assumed uniform while observations show distinct variations in megaripples over sand waves. Modelling these variations may increase in the accuracy of process-based morphological model estimates of long-term sand wave development.

This study uses the 3D process-based morphological model Delft3D in the 2DV mode. The roughness predictor VRIJN07 and sediment transport model TR2004 are used to estimate dynamic bed roughness based on hydrodynamic conditions and sediment properties. The reference case consists of a uniform Chézy coefficient of 75 $m^{0.5}s^{-1}$ (C75) combined with sediment transport model TR1993.

The results show that bed roughness influences circulation cell strength, caused by decreasing flow velocities as flow passes over the sand wave. Generally, larger bed roughness magnitudes estimated by VRIJN07 give rise to higher growth rates but shorter wavelengths. The transport model greatly influences simulation results. TR1993 combinations lead to fast growing, but short wavelengths while TR2004 combinations lead to slow growth and large wavelengths. VRIJN07 estimates negligible spatial variation due to a mechanism limiting the maximum attainable megaripple roughness height. A new roughness method is used wherein spatial variability of bed roughness is forced by linearly interpolating a Chézy coefficient of 50 $m^{0.5}s^{-1}$ at the sand wave crest and 80 $m^{0.5}s^{-1}$ at the trough (Cspatial). These spatial differences cause increased erosion at the crest, while decreasing it at the trough. In the long term, this limits the equilibrium height of sand waves to 6.2 meters. Compared to C75/TR1993 with 8.8 meters, this is a large improvement towards the average sand wave height in the North Sea of 6-7 meters. VRIJN07/TR2004 severely overestimates these averages with approximately 13 meters.

C75/TR1993 provides simulation results with reasonable agreement to field observations. Using VRIJN07/TR2004 for (spatio)temporal bed roughness modelling with the presented setup is not recommended, but results could be improved through calibration. Cspatial/TR1993 provides a significant improvement of modelling equilibrium sand wave heights under North Sea conditions. This implies that modelling spatial variation in bed roughness rather than temporal variation has a larger impact on improving simulation results. Further research should focus on extending the model with an asymmetrical tide and wind-currents and -waves to better represent field conditions.

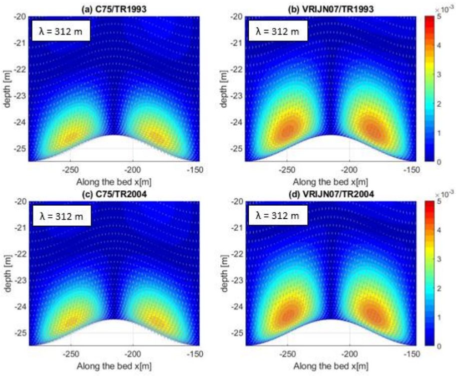


Figure 1: Tide-averaged flow velocity magnitude and circulation cells for C75(a,c) and VRIJN07(b,d) combined with TR1993(a,b) and TR2004(c,d) on a fixed wave-length of 312 meters. Note that the flow velocity on the right side of the sand wave represents negative flow velocities and convergence towards the crest occurs.

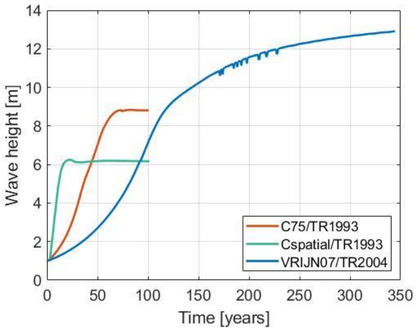


Figure 2: Development of the sand wave height over time in years for C75/TR1993, Cspatial/TR1993 and VRIJN07/TR2004.

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